38 Extension Note

August 1999

Growth Intercept Models for Western Larch

Ministry contact:
Gordon D. Nigh
B.C. Ministry of Forests
Research Branch
P.O. Box 9519 Stn Prov Govt
Victoria, BC V8W 9C2

David Brisco and David New
Faculty of Forestry
University of British Columbia
270 - 2357 Main Mall
Vancouver, BC V6T 1Z4

Abstract

Western larch (*Larix occidentalis* Nutt.) commonly grows in mixed stands, and is a relatively important tree species in the Nelson Forest Region. Researchers at the University of British Columbia undertook a larch productivity study, which included collecting data from 114 stem analysis plots. Of these, 99 plots were suitable for developing growth intercept models. The data were analyzed using a standard technique. The resulting set of 50 equations estimates site index for larch stands from breast height age 1 to 50. The models have accuracy comparable with those of interior spruce but are not as accurate as those for lodgepole pine.

Introduction

Western larch (*Larix occidentalis* Nutt.) is one of three species of larch found in British Columbia, the other two being alpine larch (*L. lyallii*) and tamarack (*L. laricina*) (Schmidt 1995). These species have distinct geographic ranges. Western larch's range is relatively small, from Okanagan Lake east to the western flank of the Rocky Mountains, and north to Shuswap and Columbia lakes (Parish et al. 1996). Its elevational range is limited by drought at low elevations and by cold temperatures at high elevations (Fiedler and Lloyd 1995). Alpine larch grows at higher elevations than western larch, while tamarack is found in boreal forests (Schmidt 1995).

Western larch is a shade-intolerant species and regenerates aggressively after fire (Fiedler and Lloyd 1995). However, it rarely forms pure stands; more commonly it is found in mixed stands with a wide variety of species including Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), lodgepole pine (*Pinus contorta*), Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), white spruce (*Picea glauca*), ponderosa pine (*Pinus ponderosa*), western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), western white pine (*Pinus monticola*), and paper birch (*Betula papyrifera*) (Fiedler and Lloyd 1995; Schmidt and Shearer 1995).

Site index, a measure of site productivity, is an important parameter in formulating silviculture prescriptions and growth and yield modelling for purposes such as inventory and timber supply planning. The growth intercept technique allows accurate estimates of site index to be obtained for juvenile stands; that is, stands as young as 3 years at breast height (B.C. Ministry of Forests 1995). The site index estimates are based on height growth above breast height. This extension note describes the development of a growth intercept model for western larch.

British Columbia
Ministry of Forests Research Program

106-06516/

Data

The University of British Columbia established 114 stem analysis plots in a larch productivity study. The plots were located in stands selected to cover the geographic range of western larch in British Columbia. Three sample trees were chosen from each 0.04-ha plot. The sample trees were dominant or codominant and showed no evidence of suppression or damage.

Stem analysis was done on the sample trees to obtain ring counts at known heights along the stem of each tree. These data were converted into tree height–breast height age data using the procedures described by Newberry (1991). The heights of the sample trees in each plot were averaged by breast height age up to the age of the youngest tree in the plot. This results in a set of top height–breast height age data for each plot. Plot site index is the top height of the plot at breast height age 50.

The tree height–breast height age and top height–breast height age data were plotted for each tree and plot, respectively, to identify anomalous height growth. Trees with irregular height growth were dropped from the analysis and, provided no more than one tree in the plot was dropped, the top height–breast height age data were recalculated. Plots with fewer than two suitable trees, or plots displaying anomalous growth, were deleted from the analysis. Fifteen plots were dropped, leaving 99 plots for the analysis. Twenty plots had one tree deleted. The site indices of the plots ranged from 9.70 to 26.97 m, with a mean of 19.92 m.

Methods

The development of the growth intercept model proceeded as described in the methods section in Nigh (1997a). The form of the growth intercept model is:

$$SI = 1.3 + e^{b1} \times GI_A^{b2} \qquad [1]$$

where: SI is the estimated site index, GI_A is the growth intercept (cm/yr) for breast height age A, and b_1 and b_2 are model parameters. One set of parameters was estimated for each age between 1 and 50.

Results

The formulated and simplified growth intercept models for breast height ages 1 to 50 are presented in Table 1 along with the square root of their mean squared error (RMSE). The models have sound statistical properties because there is evidence that they are unbiased, their behaviour is close to linear, and the residuals from the models are normally distributed and have equal statistical variances.

Discussion and Conclusion

This extension note makes the growth intercept technique available for western larch throughout its geographic range in British Columbia. These models are important because western larch has attributes such as fast growth, pest resistance, and desirable wood quality that make it a valuable species (Thompson 1995). Provincially, western larch makes up only 0.5% of the total volume harvested, but this species is important in the Nelson Forest Region where it comprises 5% of the harvested volume (Thompson 1995).

The growth intercept models for western larch have roughly the same accuracy as those for interior spruce (Nigh 1999), but are less accurate than the growth intercept models for lodgepole pine (Nigh 1997b). As is typical for growth intercept models, the accuracy of the model increases as tree age increases. This property should be considered in field applications.

TABLE 1 *Growth intercept models and their root mean squared error (RMSE) for breast height ages 1–50*

Breast height age (yr)	Model	RMSE	Breast height age (yr)	Model	RMSE
1	$SI = 1.3 + 6.347 \times GI^{0.2855}$	2.796	26	$SI = 1.3 + 1.163 \times GI^{0.7440}$	1.568
2	$SI = 1.3 + 6.427 \times GI^{0.2836}$	2.933	27	$SI = 1.3 + 1.104 \times GI^{0.7584}$	1.500
3	$SI = 1.3 + 5.871 \times GI^{0.3106}$	2.888	28	$SI = 1.3 + 1.042 \times GI^{0.7740}$	1.434
4	$SI = 1.3 + 5.288 \times GI^{0.3397}$	2.793	29	$SI = 1.3 + 0.9929 \times GI^{0.7886}$	1.372
5	$SI = 1.3 + 4.885 \times GI^{0.3617}$	2.722	30	$SI = 1.3 + 0.9542 \times GI^{0.8000}$	1.305
6	$SI = 1.3 + 4.621 \times GI^{0.3771}$	2.667	31	$SI = 1.3 + 0.9165 \times GI^{0.8116}$	1.241
7	$SI = 1.3 + 4.021 \times GI^{0.4135}$	2.520	32	$SI = 1.3 + 0.8857 \times GI^{0.8216}$	1.180
8	$SI = 1.3 + 3.873 \times GI^{0.4228}$	2.507	33	$SI = 1.3 + 0.8539 \times GI^{0.8325}$	1.120
9	$SI = 1.3 + 3.673 \times GI^{0.4359}$	2.481	34	$SI = 1.3 + 0.8136 \times GI^{0.8467}$	1.052
10	$SI = 1.3 + 3.389 \times GI^{0.4568}$	2.426	35	$SI = 1.3 + 0.7748 \times GI^{0.8609}$	0.9742
11	$SI = 1.3 + 3.065 \times GI^{0.4831}$	2.342	36	$SI = 1.3 + 0.7447 \times GI^{0.8726}$	0.9088
12	$SI = 1.3 + 2.789 \times GI^{0.5081}$	2.286	37	$SI = 1.3 + 0.7177 \times GI^{0.8837}$	0.8428
13	$SI = 1.3 + 2.510 \times GI^{0.5361}$	2.228	38	$SI = 1.3 + 0.6940 \times GI^{0.8937}$	0.7817
14	$SI = 1.3 + 2.296 \times GI^{0.5595}$	2.157	39	$SI = 1.3 + 0.6729 \times GI^{0.9030}$	0.7235
15	$SI = 1.3 + 2.131 \times GI^{0.5790}$	2.099	40	$SI = 1.3 + 0.6547 \times GI^{0.9114}$	0.6655
16	$SI = 1.3 + 1.974 \times GI^{0.5990}$	2.051	41	$SI = 1.3 + 0.6342 \times GI^{0.9209}$	0.6084
17	$SI = 1.3 + 1.828 \times GI^{0.6195}$	2.004	42	$SI = 1.3 + 0.6081 \times GI^{0.9332}$	0.5522
18	$SI = 1.3 + 1.691 \times GI^{0.6406}$	1.931	43	$SI = 1.3 + 0.5929 \times GI^{0.9412}$	0.4974
19	$SI = 1.3 + 1.596 \times GI^{0.6563}$	1.863	44	$SI = 1.3 + 0.5804 \times GI^{0.9482}$	0.4366
20	$SI = 1.3 + 1.516 \times GI^{0.6701}$	1.808	45	$SI = 1.3 + 0.5657 \times GI^{0.9566}$	0.3733
21	$SI = 1.3 + 1.438 \times GI^{0.6842}$	1.765	46	$SI = 1.3 + 0.5477 \times GI^{0.9669}$	0.3105
22	$SI = 1.3 + 1.359 \times GI^{0.6997}$	1.732	47	$SI = 1.3 + 0.5313 \times GI^{0.9766}$	0.2425
23	$SI = 1.3 + 1.299 \times GI^{0.7122}$	1.704	48	$SI = 1.3 + 0.5172 \times GI^{0.9855}$	0.1709
24	$SI = 1.3 + 1.247 \times GI^{0.7239}$	1.665	49	$SI = 1.3 + 0.5063 \times GI^{0.9928}$	0.09628
25	$SI = 1.3 + 1.194 \times GI^{0.7360}$	1.616	50	$SI = 1.3 + 0.4960 \times GI^{0.9998}$	0.05483

Literature Cited

B.C. Ministry of Forests. 1995. Growth intercept method for silviculture surveys. Silv. Pract. Br., Victoria, B.C.

Fiedler, C.E. and D.A. Lloyd. 1995. Autecology and synecology of western larch. *In* Ecology and management of *Larix* forests: a look ahead. W.C. Schmidt and K.J. McDonald (editors). U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. INT-319, pp. 118–22.

Newberry, J.D. 1991. A note on Carmean's estimate of height from stem analysis data. For. Sci. 37(1): 368–9.

Nigh, G.D. 1997a. A growth intercept model for coastal Douglas-fir. B.C. Min. For., Res. Br., Victoria, B.C. Res. Rep. 10.

———. 1997b. Revised growth intercept models for lodgepole pine: comparing northern and southern models. B.C. Min. For., Res. Br., Victoria, B.C. Exten. Note 11.

———. 1999. Revised growth intercept models for coastal western hemlock, Sitka spruce, and interior spruce. B.C. Min. For., Res. Br., Victoria, B.C. Exten. Note 37.

Parish, R., R. Coupé, and D. Lloyd. 1996. Plants of southern interior British Columbia. Lone Pine Publishing, Vancouver, B.C.

Schmidt, W.C. 1995. Around the world with *Larix*: an introduction.

In Ecology and management of *Larix* forests: a look ahead. W.C. Schmidt and K.J. McDonald (editors). U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. INT-319. pp. 6–18.

Schmidt, W.C. and R.C. Shearer. 1995. *Larix occidentalis*: a pioneer of the North American west. *In* Ecology and management of *Larix* forests: a look ahead. W.C. Schmidt and K.J. McDonald (editors). U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. INT-319. pp. 33–7.

Thompson, C.F. 1995. Management issues of *Larix occidentalis* forests in British Columbia. *In* Ecology and management of *Larix* forests: a look ahead. W.C. Schmidt and K.J. McDonald (editors). U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. INT-319. pp. 158–61.